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A COMPARISON OF NONCONTINGENT REINFORCEMENT AND SENSORY EXTINCTION AS TREATMENTS FOR SELF-INJURIOUS BEHAVIOR

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We compared the effects of two treatments, noncontingent reinforcement (NCR) and sensory extinction (EXT), on the self-injurious behavior (SIB) exhibited by 3 individuals with developmental disabilities. Results of a functional analysis indicated that their SIB was not maintained by social reinforcement, as indicated by undifferentiated responding across assessment conditions or higher rates of responding in the alone condition. Prior to treatment, leisure probes were conducted to identify highly preferred items for use in the NCR condition, and equipment probes were conducted to identify devices that produced the greatest behavioral suppression for use in the EXT condition. Following baseline, treatment was implemented in a multiple baseline across subjects design, and the effects of NCR and EXT were compared in a multielement format. During NCR sessions, participants had continuous access to a highly preferred item. During EXT sessions, participants wore equipment (gloves or protective sleeves) that seemed to attenuate stimulation directly produced by their SIB, while still allowing the behavior to occur. Results indicated that both procedures were effective in reducing SIB, although NCR was associated with either more rapid or greater overall response suppression.

DESCRIPTORS: automatic reinforcement, functional analysis, self-injurious behavior, noncontingent reinforcement, protective equipment, sensory extinction

Although many behavior problems in individuals with developmental disabilities are maintained by social reinforcement, some behaviors persist in the absence of social contingencies and appear to be maintained by sensory stimulation that is directly produced by the response. Examples of such behavior include highly repetitive and rhythmic actions, such as flapping hands and twirling objects (Repp & Karsh, 1990); certain destructive behaviors, such as tearing clothes (Rincover, 1978); and some forms of self-injurious behavior (SIB), such as hand mouthing (Goh et al., 1995).

Common descriptions for such behavior include "stereotypy," "self-stimulation," and "ritualistic acts." Lovaas, Newsom, and Hickman (1987) suggested that many stereotypic behaviors are maintained by perceptual reinforcement such as auditory, tactile, gustatory, vestibular, or other forms of sensory stimulation, and it is possible that distinct types of stimulation may maintain specific response topographies. For example, Goh et al. (1995) recently attempted to identify which source of tactile stimulation (to the hand or to the mouth) maintained participants' hand mouthing. By providing participants with access to objects that delivered stimulation similar to that produced by hand mouthing, they found that stimulation to the hand (or to the hand and to the mouth), but not solely to the mouth, served as an effective substitute for hand-mouth contact. It is also possible, however, that some behaviors may persist because they directly attenuate painful conditions (e.g., withdrawing one's hand from a hot pot handle). Thus, throughout this paper, we will use the term *automatic reinforcement* (Vaughan & Michael, 1982) as a functional

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description for such behaviors to emphasize their acquired (learned) nature and the fact that behavioral maintenance in some cases may be attributable to negative rather than to positive reinforcement.

Several interventions have been developed as treatments for behavior maintained by automatic-positive reinforcement. One procedure frequently reported in the literature is sensory extinction (EXT). The term *sensory extinction* was first used by Rincover (1978) and involves elimination or attenuation of stimulation produced by a behavior, while still permitting responding to occur. For example, Rincover demonstrated that carpeting a table top, which greatly attenuated sound, effectively reduced an individual's object twirling on the table. In subsequent studies, reductions in finger and arm flapping were observed when vibrators were placed on the backs of participants' hands (Rincover, Cook, Peoples, & Packard, 1979), and reductions in SIB were observed when individuals wore padded devices (Rincover & Devany, 1982). Thus, procedures described as EXT have included manipulations of the physical environment and various devices or protective equipment worn by individuals. Although EXT has been shown to be effective in a number of studies, it does not directly establish alternative forms of appropriate behavior. In addition, EXT may actually interfere with appropriate behavior if the apparatus used during intervention either restricts certain movements or attenuates sensory reinforcement produced by other responses.

Another treatment for behavior maintained by automatic reinforcement is differential reinforcement, which is usually implemented in either differential reinforcement of other behavior (DRO) or differential reinforcement of alternative behavior (DRA) contingencies. For example, Repp, Deitz, and Speir (1974) suppressed participants' stereotypy by delivering praise and food contingent on the completion of intervals during which inappropriate behavior did not occur (DRO), whereas Favell, McGimsey, and Schell (1982) decreased stereotypy by having a therapist provide social reinforcement contingent on object manipulation (DRA). However, differential reinforcement has not been found to be a highly effective treatment for behavior maintained by automatic reinforcement. Harris and Wolchik (1979) observed little or no suppression of stereotypic behavior under both DRO and DRA contingencies. More recently, Shore, Iwata, DeLeon, Kahng, and Smith (1997) found that leisure items suppressed participants' SIB when the items were freely available. However, when access to the same items was incorporated into a DRO contingency, there was no evidence of behavioral suppression. One possible explanation for the limited effectiveness of DRO and DRA procedures with individuals who engage in stereotypic behavior is that stimulation produced by the behavior is continuously available. Thus, the contingent availability of other reinforcers might suppress responding only to the extent that these reinforcers are extremely potent or if little effort is required to obtain them.

The noncontingent delivery of reinforcers (NCR) may represent a viable alternative to both EXT and differential reinforcement as a treatment for stereotypic behavior. In an early example of the use of NCR, Horner (1980) observed decreases in a variety of behavior problems when individuals were given free (noncontingent) access to leisure items. Similarly, Favell et al. (1982) found that setting the occasion for appropriate object manipulation by providing individuals with access to alternative activities effectively reduced stereotypic behavior. More recently, Shore et al. (1997), Sprague, Holland, and Thomas (1997), and Vollmer, Marcus, and LeBlanc (1994) reduced several topographies of stereotypy and SIB by providing noncon-

tingent access to competing sensory stimuli. The main advantage of NCR over both EXT and differential reinforcement is that, when reinforcement is delivered in the form of noncontingent access to leisure (manipulable) materials, behavior is suppressed in the absence of a programmed contingency. In addition, NCR (a) generally does not produce extinction bursts, (b) does not require the use of potentially restrictive devices, and (c) eliminates deprivation that may occur when an individual fails to meet criterion for reinforcement in a differential reinforcement contingency. Finally, to the extent that the alternative activity requires some form of object manipulation, NCR may strengthen and maintain appropriate behavior.

Given the potential advantages of NCR as an intervention, the purpose of this study was to compare the effects of a commonly used intervention, EXT, with those of NCR as treatments for SIB that was apparently maintained by automatic reinforcement. A second purpose of this study was to systematically identify stimuli associated with low levels of SIB for the EXT condition and stimuli associated with both low levels of SIB and high levels of object manipulation for use during the NCR condition, based on procedures similar to those described by Piazza, Fisher, Hanley, Hilker, and Derby (1996) and by Ringdahl, Vollmer, Marcus, and Roane (1997).

GENERAL METHOD

Participants and Setting

Three individuals participated in the study. All lived in a state residential facility for persons with developmental disabilities and had been referred for assessment and treatment of SIB. Ray was a 29-year-old man with profound mental retardation who had no speech but who displayed some simple signs and gestures. He exhibited frequent arm rubbing and hitting against furniture and other stationary objects, which produced skin abrasions and interfered with his participation in training programs. Monique was a 35-year-old woman with profound mental retardation who had no expressive and limited receptive language. Her SIB consisted of hand mouthing that resulted in frequent tissue damage. Ellen was a 20-year-old woman with moderate mental retardation who had some receptive and expressive language. Her SIB consisted of body picking and rubbing, which produced open sores on her skin.

The study was conducted in therapy rooms at a day-treatment program located on the grounds of the residential facility. The rooms contained chairs, a table, and stimuli relevant to various conditions of the study (see below). Two or three sessions were conducted per day, 4 to 5 days per week. Session lengths varied across experimental phases (see below).

Response Measurement and Interobserver Agreement

Ray's SIB consisted of arm rubbing, defined as a back-and-forth sawing motion of one forearm against the other forearm or against a chair. Monique's SIB consisted of hand mouthing, defined as placement of her hand into her mouth past the plane of her lips. Ellen's SIB consisted of two topographies: (a) body rubbing, defined as a back-and-forth motion of her fingers against any part of her skin, and (b) body picking, defined as penetration of the fingernails into the skin. Data were collected on these behaviors and also (during some conditions of the study) on Monique's and Ellen's object manipulation, defined as hand contact with a leisure item (object manipulation was not recorded for Ray). Data were recorded on handheld computers (Assistant Model A 102) by trained graduate and undergraduate student observers. Data on Ray's and Ellen's SIB were converted into number of respons-

es per minute. Data on Monique's SIB and Monique's and Ellen's object manipulation were converted into the percentage of 10-s intervals during which behavior occurred because the duration of these responses varied considerably.

Interobserver agreement was assessed by having a second observer simultaneously but independently record data with the first observer. When comparing observers' records, session time was divided into 10-s intervals. For frequency measures, the smaller number of observed responses was divided by the larger number of observed responses in each interval; these values were averaged across the session and multiplied by 100%. For interval measures, the number of agreement intervals was divided by the total number of intervals and multiplied by 100%. Reliability was assessed during 25% of Ray's sessions, 32.5% of Monique's sessions, and 31.3% of Ellen's sessions. Mean reliability scores for SIB were 94.4%, 95.5%, and 99.2% for Ray, Monique, and Ellen, respectively. Mean reliability scores for object manipulation were 94.7% for Monique and 98.9% for Ellen.

Phase 1: Functional Analysis

Procedure

All participants were exposed to a functional analysis to identify the maintaining variables for their SIB. Individuals were exposed to four assessment conditions in a multielement design, based on procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). Each condition was conducted in a different room by a different experimenter to enhance discrimination. Sessions were 15 min in length.

Attention. The participant, the experimenter, and a variety of leisure items were present in the room. The experimenter ignored the participant except to deliver attention (e.g., "Stop, don't do that; you'll hurt yourself") following each occurrence of SIB. This condition assessed sensitivity of SIB to positive reinforcement in the form of attention.

Demand. The experimenter used a three-prompt sequence (instruction, instruction plus demonstration, and instruction plus physical guidance) to present a series of tasks to the participant every 30 s. The experimenter delivered praise when a participant exhibited compliance but terminated the task and removed the materials for the remainder of the interval following each occurrence of SIB. This condition assessed sensitivity of SIB to negative reinforcement in the form of escape from demands.

Alone. The experimenter and all materials were absent. This condition allowed a determination of whether SIB would persist in the absence of social consequences.

Play. A variety of leisure materials were available throughout the session, and the experimenter interacted with the individual on a fixed-time 30-s schedule independent of the participant's behavior. Interaction included social comments, physical contact, or delivery of leisure materials. This condition served as a control for the other conditions.

Results

Figure 1 shows results of the functional analyses for Ray, Monique, and Ellen. Ray exhibited high and variable rates of SIB (arm rubbing) across conditions. His SIB occurred at somewhat lower rates during the attention condition, perhaps because the verbal reprimand delivered as a consequence functioned as punishment. Monique also exhibited variable levels of SIB (hand mouthing) across conditions, although somewhat lower levels occurred during play (these data are reproduced from Goh et al., 1995). Ellen's SIB (rubbing and picking) occurred almost exclusively in the alone condition. Although additional (extended) alone sessions were not conducted with the participants as

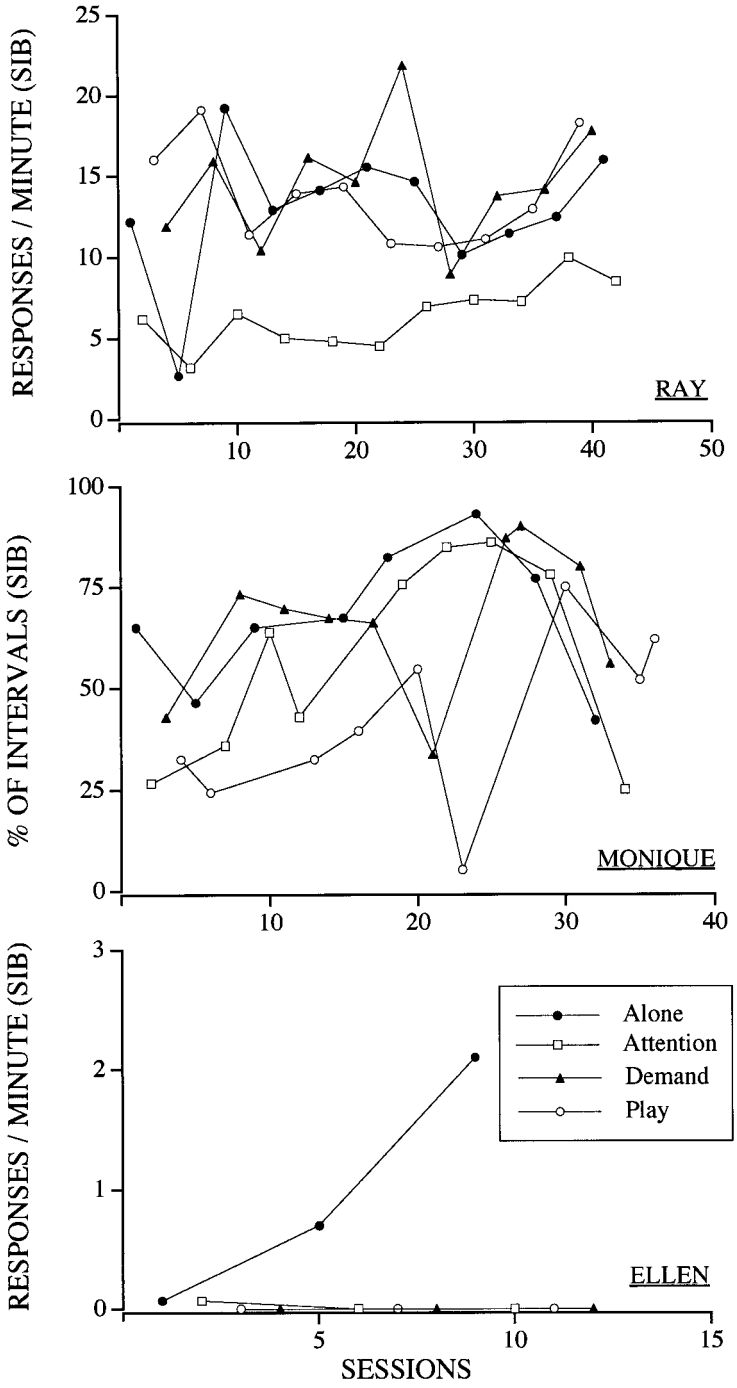

Figure 1. SIB observed during functional analysis conditions for Ray (top panel), Monique (middle panel), and Ellen (bottom panel).

a formal part of their functional analyses (Vollmer, Marcus, Ringdahl, & Roane, 1995), all 3 participants were observed on numerous occasions to engage in high rates of SIB outside of sessions in the absence of any social stimulation. Thus, none of the participants' SIB appeared to be differentially sensitive to social contingencies during the functional analyses, whereas it occurred at high rates in the absence of social interaction (both during functional analysis sessions and at other times). Both of these results are consistent with a conclusion that SIB was not maintained by social reinforcement.

Phase 2: Stimulus Selection Procedures

Both NCR and EXT are subject to numerous procedural variations based on the types of stimuli selected for use in NCR sessions and on the types of equipment or apparatus used during EXT. Thus, it is likely that behavioral suppression (or a lack thereof) under either procedure is a function of the specific stimulus or apparatus chosen. Prior to initiating a comparison between NCR and EXT procedures, both of which were designed to be maximally effective, a series of probes was first conducted to determine how both conditions would be implemented on an individual basis.

Leisure Item Selection

To identify a reinforcing activity that was highly likely to compete with (i.e., suppress) SIB, individuals were given free access to several arbitrarily selected leisure items, presented singly for 5 min (i.e., one 5-min probe for each item). During these leisure probes, data were collected on SIB and on object manipulation, as described previously. Formal leisure probes were not conducted for Ray because he was frequently observed to manipulate a dumbbell massager outside of sessions, and because staff reported decreased levels of SIB when he had access to this item.

Table 1
Results Obtained During Leisure Item and Equipment Probes

Probe	Name	Stimulus	SIB	Other manipulation
Leisure items	Monique	Wind-up car	10.0	100
		Vibrating ball	1.7	100
		Rattling car	0	93.4
		Plastic ring[a]	0	96.7
		Squeeze ball	0	100
	Ellen	TV/VCR	0	90
		Musical piano	0	100
		Balloon	0	100
		Bumble ball	0	100
		Vibrating pen	0	100
		Rap pad[a]	0	100
Equipment	Ray	Jacket	10.9	
		Sweater	7.6	
		Jacket and gloves	5.0	
		Foam sleeves[a]	0.3	
	Monique	Boxing gloves (oversize)	48.3	
		Dermapore gloves	37.0	
		Puffy gloves	37.0	
		Kitchen gloves	10.8	
		Boxing gloves (fitted)[a]	6.3	
	Ellen	Latex gloves[a]	0.1	

Note. Data on SIB are expressed as responses per minute for Ray and Ellen and as percentage of observation intervals for Monique. Data on object manipulation are expressed as percentage of observation intervals.
[a] Indicates item used during treatment.

Protective Equipment Selection

To identify an apparatus that would effectively mask or attenuate sensory stimulation produced by SIB, several types of protective equipment were placed on the participant, individually for 5 min each. Occurrences of SIB were recorded as described previously.

Results

Results obtained during the leisure and equipment probes are summarized in Table 1. During the leisure probes, a squeeze ball occasioned the lowest levels of SIB and the highest levels of object manipulation for Monique, but this item was not selected be-

cause she often placed the entire ball in her mouth, which was deemed to be a potential health risk. Thus, a plastic ring, which also was associated with low levels of SIB and high levels of object manipulation, was selected instead. Several items occasioned no SIB and continuous object manipulation for Ellen, and a small musical keyboard (rap pad) was selected as her reinforcer. Based on data obtained during the equipment probes, foam sleeves, boxing gloves, and latex gloves were selected for Ray, Monique, and Ellen, respectively. Ellen received only one equipment probe because the first apparatus tested (the latex gloves) suppressed SIB almost completely.

Phase 3: Treatment Comparison

Following baseline, a comparison was conduced between NCR and EXT, using stimuli selected on the basis of data collected during the leisure and equipment probes. The comparison was conducted in a multielement format, with treatment implemented in a multiple baseline design across participants. All sessions were 10 min in length.

Baseline

These sessions were similar to those of the alone condition of the functional analysis. This condition served as the control for the subsequent NCR and EXT conditions because it contained neither leisure materials nor any type of protective equipment. An experimenter was present in the room to control for experimenter presence during subsequent NCR and EXT conditions; however, the experimenter did not interact with the participant during the session.

Noncontingent Reinforcement

At the beginning of each session, an experimenter handed the designated leisure item to the participant, who had continuous access to the item throughout the session. As in baseline, the experimenter did not interact with the participant during the session, except to return the item to the participant if it was dropped (this happened rarely).

Sensory Extinction

At the beginning of each session, an experimenter placed the designated equipment on the participant, where it remained throughout the session. The experimenter did not interact with the participant during the session, except to reapply the equipment if a participant attempted to remove it (this happened rarely).

Results

Figure 2 shows results obtained during baseline and during the NCR and EXT treatment conditions. During baseline, Ray's arm rubbing, Monique's hand mouthing, and Ellen's rubbing and picking were rather variable (M = 16.3 responses per minute, 46.9%, and 0.8 responses per minute, respectively). The NCR condition was associated with a rapid and large response suppression for all 3 participants (M = 1.3 responses per minute for Ray, 2.8% for Monique, and 0.05 responses per minute for Ellen). Extinction was also associated with response suppression for all participants (M = 5.7 responses per minute for Ray, 12.2% for Monique, and 0.4 responses per minute for Ellen). However, the rate of reduction in SIB during EXT was not as rapid (Ray and Monique) or the overall reduction was not as large (Ray and Ellen) as that observed during NCR. In addition, reductions in SIB during the EXT condition were not as great as those observed during the equipment probes for either Ray or Monique (cf. Figure 2 with Table 1).

During NCR sessions, the mean percentages of intervals containing object manipulation by Monique and Ellen were 90.4% and 97%, respectively (this response was not recorded for Ray). These data reflect an inverse relationship between SIB and object manipu-

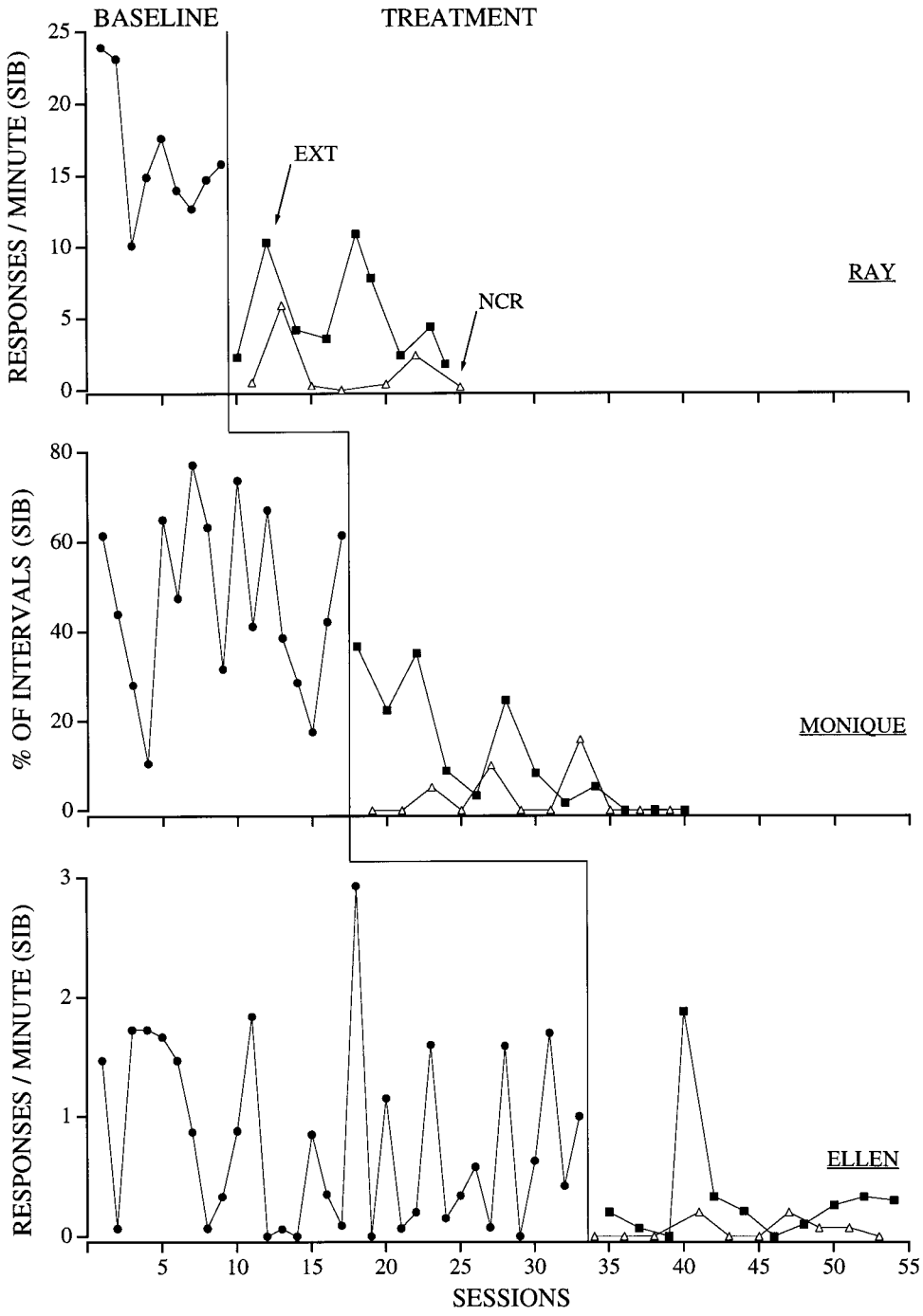

Figure 2. SIB observed during baseline and treatment (NCR vs. EXT) conditions for Ray (top panel), Monique (middle panel), and Ellen (bottom panel).

lation, in that low levels of SIB were associated with high levels of item contact in the absence of contingencies placed on either response.

DISCUSSION

Results obtained in the present study indicated that SIB, which was not maintained by social reinforcement (Phase 1), decreased during brief probes (Phase 2) when certain leisure items were available noncontingently (leisure probes) or when certain types of protective equipment were worn (equipment probes). When the effects of noncontingent presentation of leisure items (NCR) and equipment (EXT) were compared directly during more extended sessions (Phase 3), both procedures produced marked reductions in SIB, although either more rapid or more complete suppression was observed under the NCR condition.

These results have several implications for treatment. First, because both NCR and EXT were effective in producing significant reductions across different topographies of SIB, it appears that either may be an effective intervention that can be combined with differential reinforcement or used instead of differential reinforcement when results obtained with differential reinforcement are limited (e.g., Harris & Wolchik, 1979; Shore et al., 1997). Second, NCR and EXT may be used in combination to eliminate the need for more intrusive or effortful procedures such as restraint or response blocking. For example, assuming that protective equipment may interfere with some forms of adaptive behavior, leisure item probes may be conducted to select stimuli that will effectively compete with SIB for brief periods of time when the equipment is removed. Thus, individuals would have access to items that competed with SIB and simultaneously allowed them to engage in other appropriate behaviors. Third, NCR, as used in this study, may have additional advantages because (a) it required little effort to implement, (b) it produced somewhat better response suppression than did EXT even though NCR contained no extinction component (i.e., under NCR individuals could choose to manipulate the leisure item or to engage in SIB), and (c) it occasioned appropriate alternative behavior in the absence of any programmed contingencies.

It is important to note that the high degree of effectiveness observed for both NCR and EXT may have been a function of the assessment probes undertaken prior to conducting the treatment comparison (Piazza et al., 1996; Ringdahl et al., 1997). We conducted these probes in an attempt to ensure that the two treatment procedures, whose effects may have been heavily dependent on specific stimulus characteristics, would be roughly equated. Although most of the leisure items that were probed occasioned low levels of SIB and high levels of object manipulation, varying results were obtained during the equipment probes. Thus, it is unlikely that similar levels of response suppression would have been observed during the EXT conditions had the devices been selected arbitrarily. It is also possible that the devices used in this study did not eliminate SIB because they did not completely mask stimulation produced by SIB and that greater suppression might have been achieved with different devices.

Results obtained during the probes and during treatment also were interesting in terms of the apparent relation between stimulus features of the equipment and leisure items and their ability to suppress or compete with SIB. All of the devices assessed during equipment probes were initially selected because of their potential for directly attenuating stimulation produced by SIB; nevertheless, only some of the devices proved to be effective. Thus, there appeared to be a high degree of specificity for devices used during EXT. By contrast, manipulation

of the leisure items did not necessarily produce stimulation similar to that produced by SIB. For example, Ellen, whose topography of SIB was skin rubbing and picking (tactile stimulation), played notes on the keyboard (auditory stimulation) instead of rubbing it against her skin.

Thus, it seems that under certain conditions, reinforcers delivered during NCR may be quite different than those responsible for behavioral maintenance but will still produce therapeutic behavioral reduction (see also Fischer, Iwata, & Mazaleski, 1997, who demonstrated this finding for SIB maintained by social reinforcement). The mechanism by which NCR reduces behavior then becomes somewhat speculative, because access to one reinforcer probably does not eliminate the specific establishing operation (deprivation) that occasions behavior maintained by a different reinforcer. For example, access to food does not eliminate deprivation from attention. In the case of stereotypy, however, perhaps behavioral maintenance results from a more general type of sensory stimulation, such that access to a variety of alternative stimuli may eliminate a "general" state of deprivation.

The present study contained several limitations that should be noted. First, although data obtained during the functional analyses indicated that participants' SIB was not differentially sensitive to social reinforcement, specific reinforcers responsible for behavioral maintenance were not identified. Rather than to undertake a series of additional analyses to isolate the unique reinforcer maintaining each participant's SIB prior to implementing treatment, we felt that noncontingent access to preferred stimuli or the use of carefully selected devices might achieve the same therapeutic goal.

Another limitation was that we did not examine the long-term effects of either NCR or EXT. Although undesirable effects associated with chronic use of certain devices (during EXT) that restrict movement are somewhat apparent, such effects associated with NCR may not be. For example, it is possible that NCR may produce a general state of satiation such that an individual is less responsive to contingent reinforcement delivered during training sessions; alternatively, the individual may eventually be satiated by the alternative source of reinforcement and return to the target behavior. Although we did not collect any formal follow-up data on the long-term effects of either NCR or EXT, participants' discharge recommendations included the use of NCR, and we are currently conducting a study on the long-term effects of NCR within and across days. In addition, future research could explore maintenance effects of NCR to determine (a) what constitutes satiation in terms of response decrement, (b) what independent variables induce satiation, and (c) what measures can be taken to prevent or alleviate satiation.

Finally, it is unclear whether the behavioral suppression observed when participants wore the devices was actually a function of extinction instead of punishment or time-out (see Mazaleski, Iwata, Rodgers, Vollmer, & Zarcone, 1994, for a more extensive discussion of this point). For example, the foam sleeves placed on Ray's arms may have punished his arm rubbing and hitting rather than merely attenuating the sensory stimulation produced by the behavior. The equipment also may have functioned as time-out to the extent that access to other types of reinforcers may have been limited while equipment was worn. Behavioral reductions obtained while protective equipment was worn were somewhat gradual and did not show the initial burst that is sometimes observed during extinction procedures. It is possible, of course, that the equipment produced extinction, but that bursting did not occur because the equipment served as a highly salient stimulus that enhanced discrimination. Additional research is needed to

identify the mechanisms by which protective devices suppress behavior.

In spite of these limitations, the present results demonstrated that noncontingent access to preferred leisure items may be as effective as or more effective than protective devices used in an attempt to extinguish SIB apparently maintained by automatic reinforcement. Given the additional advantages associated with NCR, it appears to be a preferred treatment over interventions aimed at extinguishing behavior that is apparently maintained by automatic reinforcement.

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STUDY QUESTIONS

1. What are two commonly prescribed treatments for behavior problems that are maintained by automatic reinforcement, and what are some limitations of these treatments?

2. What are the potential advantages of noncontingent reinforcement (NCR) as a treatment?

3. Given the response definition provided for object manipulation (Monique and Ellen), which stimulus (potential reinforcer) listed in Table 1 does not seem well suited to manipulation?

4. How were participants' response patterns during the functional analysis consistent with a conclusion that their SIB was maintained by automatic reinforcement?

5. What was the rationale for conducting Phase 2 of the study, and what did it entail?

6. Describe the experimental design used in Phase 3. Why was a reversal design not used to compare the effects of sensory extinction and noncontingent reinforcement?

7. What were the results of the treatment comparison?

8. What are some potential disadvantages of NCR?

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